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Efficient Transport System in Urban Environment

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Abstract: Many cities are currently facing to problems with the functioning of their transport infrastructure resulting mainly from congestions and the increasing trend of individual car usage. The call for solving and proposing the efficient transport systems occurs due the fact of need to improve the mobility condition in the urban environment. Therefore, this paper deals with the topic of efficient transport system with accent to evaluation of single transport modes and their impact on the urban environment. The two parameters are proposed: the Capacity Index (CI) and the Vehicle Emission Pollutant Index (VEPI) that present how efficient the transport systems are in first case in the sense of transport infrastructure capacity, second in the sense of environmental issue.

Keywords: efficient, transport systems, urban, environment

JEL: R48

1. Introduction

The efficient public transport is not only related to the term of efficient as power and energy saving, but also saving the money of public authorities, citizens taxes and saving the environment. [5] This study presents the overview of research studies dealing with evaluation and analysis of various means of transport. [13, 15] This is important for evaluation of various approaches in order to ensure the objective way focused on this topic.

2. The transport systems characteristics

In the current time are presented in the urban environment mostly the following modes of transport:

- Car,
- Public transport
- Walking,
- Cycling.

The general advantage of public transport to serve for more passengers is facing to the basic problem of flexibility and problem of the “door to door” effect. That means the citizen will prefer the individual form of transport because it is more flexible and it can be used from “door to door” base. From the point of view of personal usage we can distinguish public and individual forms of transport. In Table 1 are shown the basic characteristics of presented modes of transport. Even walking and cycling have less space consumption in comparison to car, the problem of these modes of transport is that they are suitable for short distances. Especially for cycling is also need for parking facilities which are not always available in same volume as for cars.

Table 1. The comparison of particular transport systems characteristics

mode	Indiv. vs. public	parking	distance	Door to door
car	individual	yes	long	yes
PT	public	no	long	no
cycling	individual	yes	short	yes
walking	individual	no	short	yes

Cars, walking and cycling are likely to be individual forms of transport, public transport to be public form of transport. But in last decade there are presented also mixed types as carpooling, carsharing, bikesharing.[4] The theoretical advantage of public transport as ability to service to more passenger as car is generally known, but there are many factors which are necessary to take into account for understanding why the public transport has the declined trend. The study [11] defined various demand factors that have an influence on the demand for public transport. The study [10] states that in the situation where urban travel patterns become more complex, it generally becomes more difficult to serve those trips adequately by public transport and patronage levels tend to suffer as a result. By way of evidence, the results show that private transport users have the ability to react more rapidly to changes in the distribution of origin and destination activities than their public transport counterparts and this tends to confer significant advantage to users of that mode.

Moreover, the current knowledge on residential dissonance and travel behaviour indicates that the success of land use based policies is largely determined by the composition of consonant and dissonant residents living within a neighbourhood [8]. Researchers have generally adopted two approaches to disentangle the self-selection effect in establishing the causal link between environmental factors and travel behaviour. In the analysis of cross-sectional data, residential self-selection effects are controlled by taking into account a measure of travel attitudes/preferences and socio-demographics, and investigating their potential linkages.

3. Transport planning issue

There is no doubt that the systematic transport planning plays a significant role in the process of function of all transport systems in urban evidence. But the local conditions differ from city to city. Therefore, we can find the differentness between the goals in strategic documents as master transport plan and in reality where the transport systems and specially the car usage is limited just only in few ways. The study [2] provided the interesting findings in determining the basic mistakes of transport planning which are the following:

- Differentness between the proposed master plans or systematic documents and adopted measures.
- Lack of integration strategy.
- Weak participation of responsible authorities in problem solving.
- Unrealistic time scheduling for implementation.
- Lack of monitoring the strategy.
- Mostly the technical strategy is outsourced.
- Lack of data used for systematic transport planning.
- Scale of the plans and strategy.
- Lack of finance.
- Absence of interest in solving the systematic approach.

From the results shown above it is clear that the transport planning plays the important role in the process of defining the function of transport systems in the city. For example, if the city has the goal to have modal split in favour of public transport to 60% it is a problem if the city still creates the new parking places for cars and reduces the budget for public transport. Such kind of goal will not be achieved in such kind of progress. A good example can be seen in cities which are likely to implement their transport strategies in a positive way, for instance Zurich, Oslo or Odense. [7, 16, 17]

3.1. Public transport

It is proved [1] that the user satisfaction varies among different cities which have different conditions. (nie je naznačená súvislosť)The study [14] did analysis of travel time of public transport. They (kto?) found that a monopolistic, integrated service organisation was correlated with higher user satisfaction. This finding was statistically significant after controlling for a number of individual and local circumstances. The requirements of the advanced PT model (e.g. inclusion of exact departure/arrival time and various route optimisation settings) may be overwhelming for a standard user to implement in a standard GIS. Thus, not only open data but also open route search interfaces providing the necessary algorithms and computational resources on servers, make such massive analysis feasible. Indeed, reliable spatial analyses of multimodal transport — which for long have been too data hungry and computationally intensive to calculate over large extents — are now more realistic for a larger group of researchers and practitioners than what they used to be.

3.2. Developing the condition for cycling

One predominant aspect of the documents studied is that these strongly associate cycling with a positive urban vision. Negative depictions, for instance, with regard to car driving, or morally underlined claims are nowhere to be found. [3] The choice of researchers includes studies about healthy cyclists – mothers with young children, elderly, people belonging to different religious groups, overweight cyclists, as well as men in business suits –, all moving leisurely or at brisk speeds in different weather situations, conveying the message that bicycling is a cultural norm and pleasurable for everyone. Many researchers also show large numbers of bicyclists, suggesting that bicycling is a mass phenomenon. [6] In the case of Copenhagen, internal pressure to build more cycle tracks grew during the bicycle renaissance period in the late 1970s and early 1980s, when the voice of cyclists became increasingly heard in public debates. They formulated many of the policies and strategies for the bicycle city Copenhagen, and it was recognised for strong will to implement infrastructural change even in the face of resistance. The city had far-reaching ambitions, such as the goal to achieve a 50% share of commuting trips made by bike. The results point on the fact that if good infrastructure is available it can attract also more cyclists.

3.3. Environment issue

Considering the fact of traffic pollution within urban area we can compare also the range of pollution from various means of transport.

In table 2 are compared the pollutants as CO2, PM for solved means of transport.

Table 2. Comparison of pollution within modes of transport

mode	capacity	CO_2 for 10 km	CO2 per prs	PM	PM per prs
bus	100	2.1	0.021	0.13	0.0013
car	5	1.6	0.32	0.25	0.05
walking	1	0	0	0	0
cycling	1	0	0	0	0

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We can see the calculation of pollution with regarding of the number of person where the bus is presented with lower range of pollution in comparison of car with theoretical occupancy with 5 persons per car. Moreover the walking and cycling are the clearest modes of transport. Similar we can evaluate also the energy consumption where the cycling and walking represent the lower energy consumers and in opposite the car user the higher consumers.

3.4. Infrastructure capacity issue

From the point of view of the evaluation of transport network which has its own limits on capacity i.e., a limited amount of vehicles can use the infrastructure within time it is a crucial to focus and evaluate the capacity. Let's theoretically consider the junction with arm which allows for 40 second of green time the passing of various types of vehicles (the whole phase takes 90 seconds). For cars, the 32 vehicles can use the green time, which with full occupancy of 5 persons, represents the 160 person per green time. If the whole cycle takes 90 second, in one hour the maximum of 40 cycles can be realized.

Therefore the total amount of persons who will pass the junction is 6400 persons. In the comparison only 12 buses can uses the same green time with capacity of 100 persons. The one green time allow passing of 1200 persons, but with considering the 40 repeating phases it counts for 48 000 persons, see Figure 1.

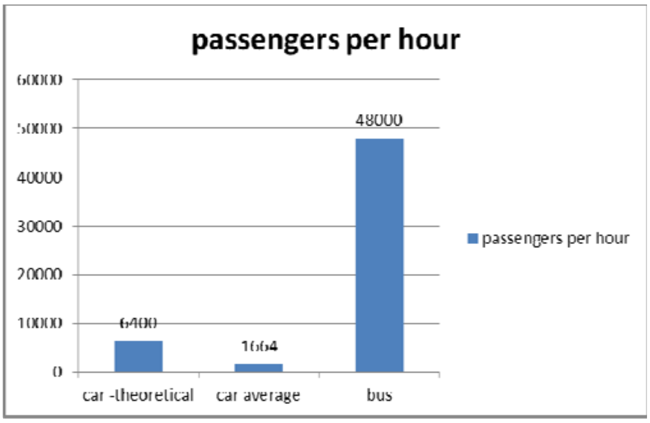

Figure 1. A theoretical comparison of vehicle capacity per one hour at junction.

Now we must say that in reality the traffic is mixed, but in theoretical comparison the efficient usage of time and capacity plays in favour of buses. Also the full occupancy in one car is more or less theoretical that means the average occupancy for a car is around 1.3 person. From this topic it is a clear advantage of public transport. If we continue in space consumption comparison we can find that the length of queue of car will be much longer that of buses.

Moreover for cyclists and pedestrians it is characterized that also in hard condition, i.e. the congestion, their traffic flow will spread out faster and will not create traffic jam as in case of cars. The benefiters are not only the passenger but all services and also for instance the freight cargo [9] serving to the city.

3.4. What is efficient for urban?

In the considering and evaluating what is efficient for the urban environment we can take into account the result presented above. The real efficient transport system is characterized by:

- fully functional transport service abilities,
- minimum of space requirement if the ratio space by persons is taken into account,
- minimum of power or energy consumption,
- minimum of public finance requirement,
- ability to serve in any location for any passenger without recognition the socio-economic status,
- minimum of unused time in operation (i.e. parking issue),
- flexibility,
- ability to cooperate with other means of transport.

For evaluation of these above mentioned factors it is recommended especially for municipalities to update and monitor their own systematic and strategic goals and to ensure if the mobility in the city corresponds to the goals which are stated in such kind of policy.

Especially for public transport it is crucial to represent one public transport system which is integrated [12,13] and does not look like a competitor in this market (for instance, the role of bus and railway.

4. Methodology for efficient analysis of transport systems

We can implement the described characteristics of particular transport systems in parameters which can be used for evaluation of efficiency of transport systems. For that reason the following parameters are proposed:

- Capacity Index (CI_i) which represent the ratio of vehicle units VU of means of transport *i* with particular occupancy O passing the particular distance per time *t*

$$\{CI\}_i = \frac{(VU_i * O)}{t} \quad (1)$$

The capacity index (CI) shows the efficient usage of transport infrastructure per time. For instance, the 4 buses with occupancy of 80 passengers and 8 cars with occupancy of 3 passengers are passing the junction per green time 20 seconds. The capacity index for bus CI_{BUS} will be calculated as:

$$\{CI\}_{BUS} = \frac{(4*80)}{20} = \frac{320}{20} = 16 \quad (2)$$

In the same way we can calculate the CI for a car.

$$\{CI\}_{CAR} = \frac{(8*3)}{20} = \frac{24}{20} = 1{,}2 \quad (3)$$

So we can see that the capacity index for a bus is higher than the capacity index for a car. The number of vehicles passing the particular distance (junction, etc.) is calculated according the basic equation of calculation the for signal timing. That means higher value of the CI represents more efficient system.

In a similar way is proposed the Vehicle emission pollutant index (VEPI) which corresponds to the number of vehicle units (VU), L is the length of a trip in km, occupancy (O) in number of persons, pollutant parameter per kilometre (PP) which can be CO2, SO_x, PM^x or other in g per km.

$$VEPI_i = \frac{(VU*L*PP)}{O} \quad (4)$$

The VEPI indices how un- environmental is the particular mode of transport which means if the value is higher the means of transport has more negative impact and produce more emissions.

5. Conclusions

This paper presents the topic of efficient transport system from various aspects which were taken into account. The conclusion says that the most efficient transport systems should be preferred from the municipality point of view by the implementation of goals of strategic transport planning policy. That means the continuous reducing of the negative impacts of transport modes.

Two indexes are introduced in analysis, the Capacity Index (CI) and the Vehicle Emission Pollutant Index (VEPI). Moreover there are big challenges in the more detail quantification of parameters which could be more understandable for municipalities in order to move them to the realization of their strategic goals leading to the sustainable mobility.

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SWOT analysis of the Slovak inland waterway transport

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Abstract: The paper deals with SWOT analysis of Slovak rivers. Although Slovak Republic is situated in the Central Europe, waterways are relatively short and not branched. Inland waterway includes commercial, sporting and tourist navigations. Commercial navigation is limited by flow volume and length of floating period. For commercial navigation have Danube, Váh and Bodrog the best conditions. All three navigable rivers do not allow maximum stable immergence use of actual vessels during the whole year. Navigable conditions (curve radiuses, fairway width, navigable depth, flow rate, flowage) are changeable during the year.

Keywords: SWOT analysis, river, inland waterway transport

JEL: R42

1. Introduction

Although Slovak Republic is situated in the Central Europe, waterways are relatively short and not branched. Total navigable length of Slovakian rivers is 172 km of which Canals are 38,45km. Inland waterway transport is partly on rivers Váh and Bodrog and on river Dunabe (following AGN agreement marked as E-80), which belongs to TEN-T and is also part of corridor VII and part of RHINE-MAIN-DANUBE waterway, but with time and local limitations. This water land allows connection to harbours in North and Black seas as well as connection to west European river lands net.

2. Slovak Rivers and Inland Waterway Transport

Inland waterway includes commercial, sporting and tourist navigations. Commercial navigation is limited by flow volume and length of floating period. For commercial navigation have Danube, Vah and Bodrog the best conditions with navigable length:

- Danube with length 172 km (Slovakian part, rkm 1708 – 1880)
- Váh with length 57 km (part Komárno – Šaľa, rkm 0,0 – 57,0)
- Bodrog with length approximately 7,5 km (border Hungary/Slovakia – Ladmovce)

All three navigable rivers do not allow maximum stable immergence use of actual vessels during the whole year. Navigable conditions (curve radiuses, fairway width, navigable depth, flow rate, flowage) are changeable during the year. Tonnage of vessels which are adequate to limited conditions and navigable length are from 800 to 1600t on Danube, till 600t on Vah and 450t on Bodrog.

3. SWOT analyses

The study "Medium and Long Term Perspectives of Inland Waterway Transport in the European Union" provided by the European Commission describes a SWOT analysis of inland waterway transport (IWT) as follows:

SWOT for IWT as seen from the supply side of transport

Internal origin - Strengths:

- sufficient fleet capacity, in particular large vessels,
- much spare capacity on waterways to foster a growth of traffic,
- high amount of flexible entrepreneurs in the market.

Internal origin - Weaknesses:

- long life-time of inland vessels and engines, resulting in high air pollutant emissions,
- ageing human resources, lack of influx, shortage of qualified staff,
- fragmented and atomised SME structure resulting in low co-operation and lack of ability to integrate IWT in door-to-door chains,
- overcapacity and small profit margins,
- limited use of ICT systems,
- missing infrastructure links, limited fairway conditions and lack of transhipment areas and multimodal connectivity,
- poor safety culture resulting in significant safety risks for workers.

External origin – Opportunities:
- funding programmes for funding of infrastructure,
- stimulating policies to strengthen supply side of IWT,
- internalising external costs: pricing of competing modes: road transport and rail.

External origin – Threats:
- growing pressure on spatial planning (e.g. housing projects conflicting transhipment functions for IWT),
- conflicts with ecology (nature reserve),
- internalisation of infrastructure costs for IWT,
- possible impact of climate change on water
- levels on long term.

SWOT of IWT activities in general as seen from the demand side:

Internal origin - Strengths:
- low freight rates,
- reliable transport operation,
- low carbon footprint,
- available transport capacity (vessels),
- available infrastructure capacity; growth potential,
- high market share in traditional sectors (captive markets for IWT such as coal, ore, oil),
- comparatively high safety levels; in particular external safety (risks for population or the environment).

Internal origin - Weaknesses:
- not all origins and destinations are located in the proximity and necessitating the use of transhipment and other modes,
- high volumes needed (consolidation), dependence on a limited number of large customers and consolidation,
- low operational speeds,
- lack of visibility and poor image at potential clients,
- varying water levels on certain corridors causing a low predictability of service levels and changing freight rates,
- high or low a water levels and accidents can block critical parts of the waterway network,
- low level of awareness in IWT of broader supply chain developments (door-to-door) and limited knowledge of marketing and supply chain management,
- industry fragmentation and reaction to external shocks (e.g. recent economic crisis)

External origin – Opportunities:
- infrastructure expansion (e.g. Seine - Schelde, Rhine-Rhone),
- commercial co-operation and increase of scale in (multimodal) logistics,
- growth of world trade resulting in steep growth of maritime container market,
- congestion on motorways and lack of capacity in rail transport,
- growing demand for low carbon transport solutions,
- attracting new markets such as waste transport, bio fuels, LNG, pallets, continental containers,
- increased awareness of safety and security problems,
- growing number and position of inland container terminals.

External origin – Threats:
- limited political support and funding resulting in poor condition of many waterways and inland ports,
- loss of markets due to energy policy (e.g. coal and fossil fuel transports),
- impact of high-oil prices on various industries that are customers of IWT,
- further liberalisation, efficiency and interoperability of rail transport markets,
- possible introduction of Long and Heavy Vehicles for road haulage (e.g. 3 TEU truck),
- increased restriction of banks for investment as a consequence of the crisis.

The SWOT analysis shows that there are many problems inside countries. Serious problem is the poor cooperation and organisation within the inland waterway transport, i.e. cooperation between carriers or with other modes of transport or communication with shippers. Another problem is a high level of fragmentation of carriers in the market. These appear to be essential weaknesses of the system. Further consolidation of the suppliers is necessary. This could be done by expanding companies and industry trade groups which would result in better operational performance, greater purchasing and marketing power and improvements to quality of door-to-door services.

Very urgent need is improvement of inland waterway transport infrastructure. It also needs a good labour market and clear rules and regulations. Otherwise it is not able to use its potential to the full.

In the waterway network there are still several missing links, such as limited depth of navigable parts or problems with low reliability and efficiency of fairways. In this respect, it is essential to provide better maintenance of fairways, including dredging.

SWOT analysis of IWT of Slovak Rivers:

Internal origin - Strengths:
- strategic geographic position of SR in transport links of West – East, North – South,
- Transport infrastructure of SR as part of trans-European transport networks (TEN-T),
- decentralization of road transport infrastructure administration,
- direct access to European transport Corridor VII (Danube – Mohan – Rhine),
- decongestion of roads in the Váh-side contributing to increased traffic flow and safety on the roads,
- savings in energy consumption by 30%, as compared with the direct long-distance transport of goods by road haulage,
- reduction of the cost per unit of transported goods,
- lowest environmental impact of traffic,
- job professions (e.g. captains, boatmen) are very perspective and demanded in the SP.
- reduction of environmental pollution by harmful emissions and noise due to their lower levels in water transportation, which makes a substantial part of the journey,

and significantly lower costs to restore environmental damage,
- lowest accident rate, low carriage costs, and lowest congestion rate in water transport,

Internal origin - Weaknesses:
- transport infrastructure within the TEN-T network is not constructed completely,
- lack of financial resources to develop transport infrastructure,
- low standard of information and communication technologies in transport,
- failing technical and qualitative condition of remaining transport infrastructure (national, regional and municipal level),
- lack on the modernisation of the fleet,
- insufficient waterway transport potential utilisation,
- low quality of transport services (public transport, integrated transport systems), lagging behind the EU 15 countries,
- low standard of transport vehicles renewal,
- insufficient navigation depth on the downstream Elbe and Danube rivers (goods may be also delayed due to the water level in rivers, where the limit is not only low, but also high water, as there are limits to the passage of ships under bridges),
- the Slovak Republic has had the lack of the qualified staff who could work in the area of IWT and logistics (The average age of the staff in the biggest shipping company called Slovak Shipping and Ports is more than 50 years old.),
- no secondary schools in the area of IWT, IWT and logistics are mentioned only in general content at secondary schools plus lack of students who want to study and work in IWT and lack of well educated nautical staff,
- negative influence on the aquatic environment,
- slowness of ships, absence of sewage stations,
- the crucial thing is that when it is necessary to get shipment “on water” railway transportation must be used, then it is loaded to the ship, and in the destination port, the entire procedure repeats,
- shortage of qualified crews and an increasing lack of entrepreneurial successors,
- obstacles: limited draught of vessels, dive clearance of bridges, locks dimensions prevent their full utilization and reduce competitiveness.
- no promotion of IWT in the SR,

External origin – Opportunities:
- national and international importance,
- capacity and efficiency of waterway,
- availability and capacity of water vessels,
- provision of sustainable mobility via supporting ecologic means of transport,
- improvement of transport quality, safety and reliability, based on intelligent transport systems,
- control and reduction of transport (via introducing fees for using the infrastructure),
- proportional development of individual types of transport infrastructure,
- improve the accessibility of SR and regions to TEN-T networks and to supra-ordinate transport infrastructure,
- reduce externalities by development of multimodal transport systems,
- increase resource allocation to transport infrastructure via multiple-resource financing of the transport infrastructure,
- increase utilisation of water transport potential,
- achieve more efficient and attractive services via regulated competition,
- new job opportunities,
- after construction of the stretch Trenčín – Piešťany other stretches of VVC can be built up to Žilina (national importance),
- upgrading of the Danube waterways, better utilization of the connection to European waterway network,
- connection to the Oder (international importance),
- creating opportunities for complex service of the area, where the number of participants in the transport chain is increasing, as well as the range of business activities,
- construction of the stretch will be a challenge for freight shipping and recreational sailing,

External origin – Threats:
- access to ports,
- the sector must constantly adapt and improve its logistics efficiency, safety, and environmental performance to new technological developments and market requirements,
- financial issues (e.g. the threat of non-earmarking funds from the state budget,
- Slovak certificates are not harmonized with other European certificates (mainly on the Rhine),
- decreased transport accessibility and thus reduced attractiveness of SR and its regions to investors,
- growth of negative impact of transport on the environment,

- deterioration in quality of transport infrastructure, caused by a lack of financial means for its development, maintenance and operation,
- congestion causing increased energy, time and economic loss which reduces the competitiveness of the Slovak economy,
- increase of transport‘s negative impact on the environment caused by a lack of financial means for renewal of public passenger transport fleet,
- qualified nautical staff is overaged (50 and more) and absence of well educated nautical staff in a near future,
- the threat of non-completion of the project due to lack of interest from towns, villages, factories, plants and insufficient funding,
- lower competitiveness when comparing to road and railway transportation,
- low demand for water freight.

In general there is not enough attention paid to the work on infrastructure to be done and the development is very slow. Insufficient maintenance provided by several member states is a problem, especially on the East-West and the Danube corridors. The existing ports and terminals in Western Europe are under pressure. On the other hand, along other corridors, such as that on the Danube, the density is insufficient.

In particular, when considering the container transport sector a high-quality and efficient international network of terminals is needed that is closely linked to factories and logistic areas as well as to other modes of transport. Lastly, better coordination is necessary in the regulatory field, one of essential points being the implementation of river information services.

4. Conclusions

Slovak rivers have big potential, but as was shown in the SWOT analysis weaknesses are stronger than strengths although there are many opportunities. Waterways offer a possibility of cheaper transport for bulk cargo and have sufficient capacities. Of course terms are usually longer but safety is higher.

Inland waterway transport of the Slovak Republic suffers from a general lack of incentives and support from the Slovak government’s side and from the fact that national transport policy is predominantly focuses on the development of the rail and road system in the country.

Potential of Slovak IWT is much higher than currently used, by success in increase of freight transport via existing IWW, the investments into Váh enhanced navigability up to port Žilina (cca 250km) can be promoted, which will be a step in building connections of Danube-Elbe-Oder, and Danube-Oder-Tisza via Váh.

ACKNOWLEDGEMENTS

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Increasing the Safety of Railway Crossings

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Abstract: This article is focused on improving safety at railway crossings and points of active and passive safety features. Following these general safety rules we can reduce or eliminate the risks that increasingly affect the right of railway crossings. The article describes redundant lock crossing time which unfavorably affects the rail crossing accidents and the solution which eliminates this factor. The paper is supported by the VEGA Agency by the Project 1/0188/13 "Quality factors of integrated transport system in the effective provision of public transport services in the context of globalisation" that is solved at the Faculty of Operation and Economics of Transport and Communications, University of Žilina.

Keywords: crossings, safety, accidents, railway crossing closure time

JEL: L92

1. Introduction

Level crossing of two communications (rail-road crossing, motorway crossing) represents, in general, enhanced risk for users of both roads. The communications conditions have to eliminate, minimize or warn of the enhanced risk, or harmful factors impacting on people situated on communications crossings, or nearby them. It is necessary therefore, to implement into the transport operations a system that is accepted by all users of communications crossings, which ensures increasing, or maintaining the safety level which fulfils a defined purpose. This purpose is the safety and continuousness of transport. The requirements on transport are increasingly challenging and it is therefore necessary to optimize and ensure also safety and continuousness of transport on level crossings and to make them more effective.

The resolution of railway crossings safety technology in the Slovak Republic is published by the Railway Transport Regulation Agency after consultation and agreement with affected authorities (e.g. Higher Territory Entities, Transport Police, etc.). The method of railway crossing safety assessment depends on the railway track type, motorway class, intensity of railway and road transportation, local conditions on both roads and, in some cases, also on the frequency of accidents on railway crossing.

The aim of this safety assessment process is to define generally valid principles of prevention and basic conditions for assurance the safety, protection and continuousness of transport and elimination of risks and factors that underlie accident inceptions, accidents and other damages to health of transportation participants on railway crossings. The priority of railway organizations is to ensure the safety and continuousness of transportation on railway crossings. The elements used for this assurance can be divided into active and passive safety elements:

- **Active safety elements** – those elements which can by their active influence reduce the probability of the accident,
- **Passive safety elements** – those elements which can by their influence reduce the after-effects on participants of the accident. [1]

2. General Principles of Safety Assurance on Railway Crossings

It is a genuine obligation of every participant on transportation process to follow safety transport rules on railway crossing. These rules result from general principles of safety assurance:

- to eliminate danger and threats and risks resulting from them,
- to accomplish precautions with the respect for all circumstances relative to transport, in accordance with legal acts and other directives to ensure safety and continuousness of transportation,
- to detect the risk,
- to evaluate the risk,
- to evaluate risks which cannot be eliminated, especially when choosing and using transport means,
- to take actions on liquidation of danger in the place of their inception,
- to liquidate danger and threats, and if it is, according to achieved science and technical skills, not possible, to

take actions for their eliminations and to prepare actions for their liquidation,

- to prefer collective protect actions against individual protect actions,
- to adapt transport to driver skills and technical progress,
- to respect personal skills, features and abilities, especially when operating transport, when choosing transport means, procedures in transport, with the aim to eliminate or alleviate effects of dangerous factors,
- to plan and to carry out policy of prevention by implementing safe transport means, technologies and methods of transport organization and by increasing quality of transport roads respecting the factors of the environment,
- to plan and to carry out policy of prevention by implementing social actions,
- to publish directives and instructions to assure safety and continuousness of transport. [2]

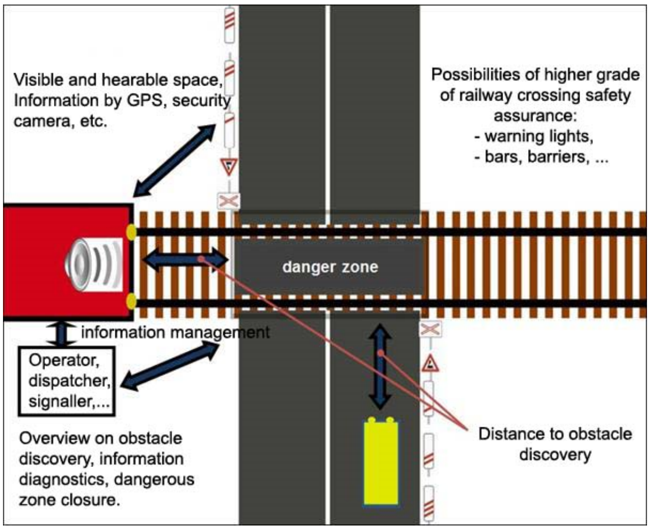

Figure 1. Basic layout of level railway crossing.

3. Factors Influencing the Safety on Railway Crossings

Several factors influence safety and continuousness of transportation on railway crossings. The main of these factors are:

- speed,
- human factor,
- transportation character,
- transport infrastructure,
- transport means,
- valid legal acts. [3]

Human factors influencing the safety and continuousness of transportation on railway crossings are also incorrect reactions of participants of transport situations. Incorrect reactions of participants of transportation on railway crossings are influenced by several impacts which have to be analyzed and researched in detail.

Partial impact on incorrect reaction of participant of transport situation on railway crossing is also long time, or frequent waiting of road transportation participants in front of closed railway crossing or in front of light signalling device of railway crossing safety device. Unpredictable reactions of road transportation participants, leading often to deadly injuries, damages to health, or to property damages of considerable values can be the consequence of long time waiting.

It is necessary to analyze in detail the conditions of each railway crossing individually for the purpose of investigation of long time waiting reasons. This is necessary because the factors influencing the time of waiting are very specific. However, the basic layout of a level railway crossing shown in Fig. 1 is valid for every railway crossing in general.

4. Basic Influences on Excessive Time of Railway Crossings Closure

From a detailed observation we found out that there are several types of influences on excessive time of railway crossing closure:

- marking and type of assurance of railway crossing
  - category of assurance,
  - marking,
- location of railway crossing considering railway transportation character
  - in railway station,
  - on track,
- speed of railway vehicle
  - railway crossings depending on speed of railway vehicle,
  - railway crossings independent of railway vehicle speed,
- technology of work,
  - possibilities of informing,
  - ways to confirm railway crossing closure,
- way of railway vehicles operation through railway crossing
  - consecutive runs,
  - contrary runs,
- trains intended for specific type of transportation
  - passenger trains only,
  - freight trains only,
  - passenger and freight trains,
- number of tracks on railway crossing
  - single track crossings,
  - double and more track crossings,
- shut-out actions of railway infrastructure manager
  - permanent,
  - short-period,
  - emergency situations,
- space possibilities of infrastructures
  - opacity,
  - geometrical layout of railway crossing,

- incorrect operation of railway crossing devices.

5. The Impact of Railway Vehicle Speed on Railway Crossing Closure Time

According to our statistical research and observations of single track railway crossings and according to generally valid formula for time calculation, we calculated necessary time for single track railway crossing closure for each approaching distance used on the network of Slovak Railways (ŽSR), which are 400 meters, 700 meters and 1 000 meters. We also calculated real time of railway crossing closure and, subsequently, we derived the formula for calculating excessive time of railway crossing closure with the respect to speed of railway vehicle:

$$T_{nut} = L_p \;/\; V_{max.dov} \quad [\text{min}] \;, \tag{1}$$

where:

T_{nut} – necessary time for railway crossing closure,

L_p – railway crossing approaching section length for railway vehicle,

$V_{max.dov}$ – maximum allowed speed of railway vehicle,

$$T_{sku} = L_p \;/\; V_i \quad [\text{min}] \;, \tag{2}$$

where:

T_{sku} – real time of railway crossing closure,

L_p – railway crossing approaching section length for railway vehicle,

V_i – actual speed of railway vehicle,

$$T_{nadb} = T_{sku} - T_{nut} \quad [\text{min}] \;, \tag{3}$$

where:

T_{nadb} – excessive time of railway crossing closure,

T_{sku} – real time of railway crossing closure,

T_{nut} – necessary time for railway crossing closure.

Graphic description of necessary and excessive time of railway crossing closure for determined speed of railway vehicle is shown in Figs. 2, 3 and 4.

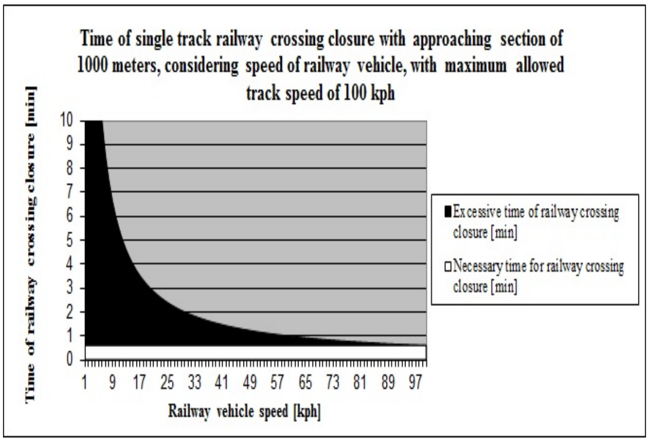

Figure 2. Time of railway crossing closure with approaching section of 1 000 meters.

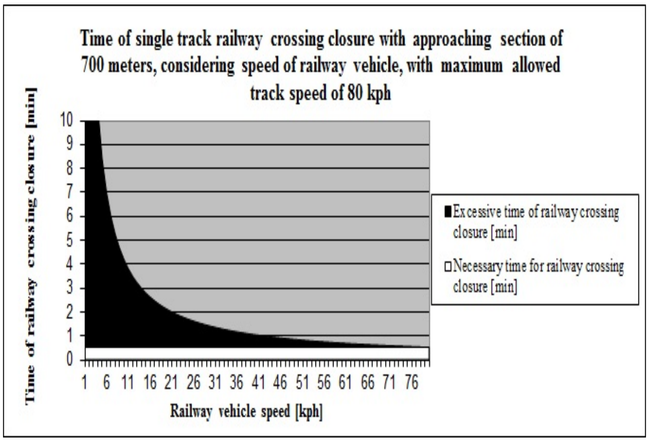

Figure 3. Time of railway crossing closure with approaching section of 700 meters.

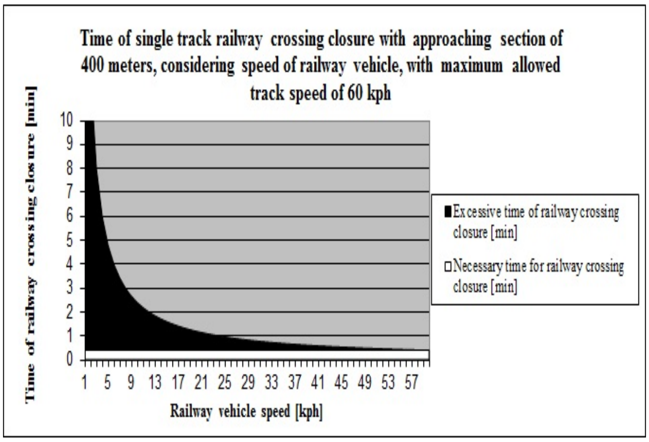

Figure 4. Time of railway crossing closure with approaching section of 400 meters.

Figure 5. Passenger train No 3509 on single track railway crossing with light- equipped interlocking device with bars in Railway station Žilina district.

Table 1. Numbers of secured railway crossings in Slovakia in the past years

Number of secured railway crossings in Slovakia / years	2007	2008	2009	2010	2011
warning cross	2307	2265	2220	2219	2205
railway crossing interlocking device	1085	1102	1076	1081	1079
mechanical bars (including 20 permanently locked)	123	103	100	98	94
light-equipped railway crossing interlocking device	962	999	976	983	985

6. Accident Occurrence on Railway Crossings

Railways of the Slovak Republic (ŽSR) has marked every railway crossing with the system of unique identification number of railway crossing for the purpose of signaling possible risk, or for eliminating the consequences of accident. This mark is black number on white ground in reflex foil (for better visibility in conditions of reduced visibility). In case of emergency it is necessary to report this number on emergency telephone number 112. Samples of identification numbers of railway crossings are shown in Fig. 6.

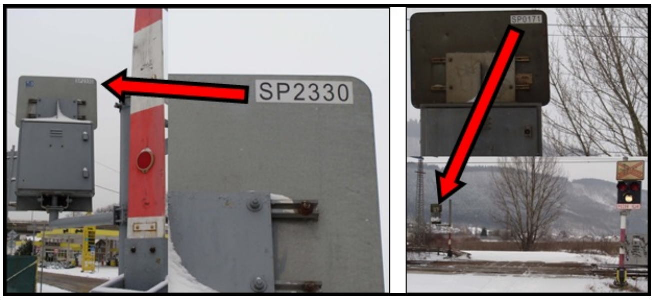

Figure 6. Unique identification numbers of chosen railway crossings.

A leading employee of ŽSR organizational unit in whose district the accident happened is responsible for organizational assurance of liquidation works and a possible substitution for passenger transportation. He cooperates with a control dispatcher, train dispatcher from organizational unit management and leading employees of participating organizational units. He is responsible for a detailed observation and analysis of on-line recordings at electro-dispatcher. Authorities of ŽSR (infrastructure manager) and railway transport operator authorities do act together and coordinately when accident occurs on railway crossing.

Table 2. Accidents on railway crossings and their consequences

Slovak Republic / years	2011	2012
Number of accidents	140	136
Departed	15	11
Seriously injured	41	68
Slightly injured	19	20

7. Conclusions

It is possible to prevent the accidents on railway crossings which occur in everyday life taking preventative measures together with implementing new technologies into operations. Present technologies used in practice do not use the kinetic component of train movement which expressly influences the time necessary for railway crossing closure. However, this component is just one of the factors which impacts on excessive time of railway crossing closure. The excessive time of railway crossing closure influences the reactions of road transportation participants on the railway crossing and it negatively affects their behaviour. Elimination of this excessive waiting time can, therefore, cause the increase of safety and decrease of potential risks on railway crossings. Safety maintenance has to be and is the top priority in the chart of obligations of transportation process participants, on railway crossings. The investments to increase safety of railway crossings cannot be limited as they are negligible when compared to the price of a human life. This is the reason why grade-separated railway crossing is becoming the best solution which completely eliminates the excessive time of railway crossing closure.

The paper is supported by the VEGA Agency by the Project 1/0188/13 ”Quality factors of integrated transport system in the effective provision of public transport services in the context of globalisation “ that is solved at the Faculty of Operation and Economics of Transport and Communications, University of Žilina.

Figure 7. Grade – separated railway crossing.

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Evaluation of Effectiveness of Regional Airports in Central Europe by Data Envelope Analysis

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Abstract: In the paper we evaluate economic efficiency of 20 regional airports in Central Europe (Bratislava capital airport including) within 2004 – 2010 using input oriented data envelope analysis (DEA) with constant return on scale to identify super efficiency score. The paper results contribute to airport economic benchmarking literature which is still insufficient just for airports of regional nature. Covering 12 economic inputs and outputs parameters our research revealed Bratislava airport as efficient all the period within the sample analyzed which may be subsequently used as a supportive argument when stating development strategy for Bratislava airport.

Keywords: effectiveness, regional airport, Central Europe, DEA, benchmarking

JEL: L93

1. Introduction

The production of air transportation services is characterized by two vertically separated levels. "Up stream" level of the market is ensured by infrastructure aviation entities, airports included which provide necessary aeronautical infrastructure and infrastructure services for air carriers. Airports as economic entities are unique systems not only with regard to technology used but also taking into account specific exogenous and endogenous economic drivers of airports business in the corresponding airport markets. Traditional comprehension of airports in managerial practice and in economic research as well is in the state of flux reflecting changes in ownership and governance of airports in the world. Many airports which were historically only administrative ministerial arms without any autonomous competencies are nowadays modern business entities of decentralized, commercialized, corporatized and/or privatized companies[1] running their activities on partially or fully commercial basis. It has created natural pressure on research of airports economic effectiveness in theory and practice as well.

Economic research of airports effectiveness used originnaly a system of partial indicators in four areas – labour and capital productivity, profitability, costs intensity and revenue generation.[2] Any of the indicators used expressed different dimensions of airport effectiveness which was without any doubt very useful for everyday managerial decisions. However, this approach did not enable to assess airports effectiveness by one complex parameter.[3]
In 1997, Gillen and Lall published the first study aimed at airports effectiveness by Data Envelope Analysis (DEA) to reveal effectiveness of 21 airports in the USA covering period 1989 – 1993. [7] The study encouraged an emergence of similar studies focusing on measurement of economic effectiveness of airports by multidimensional methods – DEA, stochastic production function (SPF) and total factor productivity (TFP). The research swing to multidimensional methods was clearly formulated by Humpreys et al. in 2002: "Highly quantitative methodologies such as data envelope analysis (DEA) and total factor productivity (TFP) have been applied to airports in order to measure inputs in relation to outputs. [17] In Table 1 we introduce overview of airports effectiveness research milestones according to the method used covering papers published between 1997 – 2010 and in Table 2 we characterize the papers according to number of airports and time period analyzed. As we can see

[1] The first wave of airports privatization started by BAA privatization in Great Britain (London Heathrow, London Stansted, London Gatwick) by IPO method at the eighties. The process continued by privatization of regional airports in Great Britain (Cardiff, East Midlands, Belfast etc.) spilling to other parts of the world. In Europe, IPO method was used for airports privatization in Vienna, Kopenhagen, Rome, Zurich etc. Direct sales were applied in airports privatization in Liege, Brussels, and Dusseldorf etc. Approaches to airports privatization are discussed more in Cruz – Marques [15]. Airport Council International estimates that partially or fully privatized airports cover about 48 % of passengers handled by European airports. [2].

[2] Revenues of airports are generated by aeronautical activities and services and non-aeronautical activities and services. In 2001 non aeronautical revenues represented 15 % of the total revenue of world airports presently they account about 46 % of the total revenues of world airports. [7].

[3] Partial indicators are still used in practice and they are still very important in economic benchmarking of airports provided by the world air research laboratories - ATRS, GARS, TRL.

in the tables the measurement of effectiveness started to be accompanied by effort to test drivers of effectiveness such as ownership structure, regional economic growth, size of airports catchment area, local airports competition. It is natural that the research has been concentrating on large airports which catch a significant proportion of world demand for air transportation services.

Table 1. Overview of airports effectiveness research milestones

Author(s)	Airports Number, Airports Localization	Period Analyzed
Gillen/Lall (1997)	21 USA	1989-1993
Hooper/Hensher (1997)	6 Australia	1989-1991
Graham/Holvad (1997)	25 Europe 12 Australia	1993
Vasigh/Hamzaee (1998)	7 USA	1990-1993
Parker (1999)	32 Great Britain	1988/89-1996/9
Murillo-Melchor (1999)	33 Spain	1992-1994
Jessop (1999)	32 world	1997-2002
Nyshadham/Rao (2000)	25 Europe	1995-1997
Sarkis (2000)	44 USA	1990-1994
Pels/Nijkamp/Rietveld (2001)	34 Europe	1995-1997
Gillen/Lall (2001)	22 USA	1989-1993
Martin/Roman (2001)	37 Spain	1997
Abbott/Wu (2002)	12 Australia	1990-2000
Martin-Cejas (2002)	40 Spain	1997
Pacheco/Fernandes (2003)	35 Brazil	1998
Bazargan/Vasigh (2003)	45 USA	1996-2000
Holvad/Graham (2003)	21 Great Britain	1993-1997
Pels/Nijkamp/Rietveld (2003)	33 Europe	1995-1997
Sarkis/Talluri (2004)	44 USA	1990-1994
Barros/Sampaio (2004)	13 Portugal	1990-2000
Yoshida (2004)	30 Japan	2000
Yoshida/Fujimoto (2004)	43 Japan	2000
Kamp/Niemeier/Mueller (2005)	17 Europe	1998-2003
Vogel (2006)	35 Europe	1990-2000
Lin/Hong (2006)	20 world	2003
Vasigh/Gorjidooz (2006)	22 Europe, USA	1900-1999
Oum/Adler/Yu (2006)	116 world	2001-2003
Barros/Dieke (2007)	31 Italy	2001-2003
Oum/Yan/Yu (2008)	109 world	2001-2004
Fung/Wan/Hui/Law (2008)	25 China	1995-2004
Barros (2008)	27 Great Britain	2000-2005
Barros/Assaf/Lipovich (2008)	31 Argentina	2003-2007
Tseng/Ho/Liu (2008)	20 world	2001-2005
Mueller/Ulku/Živanovic (2008)	7 Great Britain a 6 Germany	1998-2005
Curi/Gitto/Mancuso (2009)	36 Italy	2001-2003
Barros/Weber (2009)	27 Great Britain	2000-2005
Suzuki/Nijkamp/Pels/Rietveld (2009)	19 Europe	2003
Martin/Roman/Voltes-Dorta (2009)	37 Spain	1991-1997
Assaf (2010)	27 Great Britain	1998-2008

Only one paper of Fung et al. within the list covered by this paper investigated regional airports. The papers introduced are different also with regard to inputs and outputs included in analyses, mainly in inputs parameters where a higher diversity is recorded (number and capacity of runways, stands numbers, numbers of check-in decks, assets value, number of employees, costs values totally or according to costs categories etc.)[4] As for methodology used, DEA was the most frequent within the studies. Applied independently or in combination with SFA or TFP methods, DEA was used in 29 of the studies mentioned. None study focused on airports explicitly in Central Europe nor yet European regional airports.

2. Methodology

In our research we focused on efficiency of regional airports in Central Europe. The term regional airport per se requires deeper explanation as it is strongly influenced by analytical context. In the European Union there is none unambiguous definition of regional airport. According to the opinion expressed in the EU document The capacity of regional airports (CdR 393/2002) adopted on 2 July 2003, regional airport is any airport with passengers handled between 200 000 and 5 million per year. The document states that under some circumstances also airports with passengers handled over five million up to ten million per year can be considered as regional ones. In the Communication from the Commission named Community Guidelines on Financing of airports and start-up airlines departing from regional airports (2005/C 312/01) regional airports for the purposes of the guidelines are split into two categories – small regional airports with passengers fewer than one million per year and big regional airports with passengers handled from one to five million per year. The Decision No 661/2010/EU of the European Parliament and of the Council of 7 July 2010 on Union guidelines for the development of the trans-European transport network define airports of common interest composed of international connecting points, Union connecting points and regional connecting and accessibility points. The airports serving functions of regional connecting and accessibility points include all airports with an annual traffic volume of between 500 000 and 899 999 passenger movements, of which less than 30 % are non-national, or with an annual traffic volume of between 250 000 minus 10 % and 499 999 passenger movements, or with an annual traffic volume of between 10 000 and 49 999 tons freight throughput, or located on an island of a Member State, or located in a landlocked area of the Union with commercial services operated by aircraft with a maximum take-off weight in excess of 10 tons. The regional connecting or accessibility points must be situated out of the area with radius of 100 km from the nearest international connecting point or Union connecting point. Within this airport categorization only those airports important for development of transeuropean transport network are taken into account, therefore such definition will not cover all regional airports narrowing in this scope the EU regional airports. Therefore, we included in our analysis twenty airports in Central Europe from four Member States – the Slovak Republic, the Czech Republic, Poland and Aus-

[4] We fully agree in this with Klieštik who stated: “in case of transport companies a decision about parameters expressing inputs and outputs is not simple and unambiguous...“ [31]

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tria in time period of seven years.[5] Regional nature of the airports chosen is given mainly by performance indicator expressed through number of passenger handled per year. No of the airports analyzed did not exceed 3 million value annually which corresponds with regional airport definition stated by the EU document about the capacity of regional airport. Three of the airports are in line with micro-airports category with performance lower than 200 000 passengers handled per year. According to the Communication from the Commission named Community Guidelines on Financing of airports and start-up airlines departing from regional airports we worked in our analysis with categories of small regional airports (Poprad-Tatry, Žilina, Pardubice, Brno, Košice, Ostrava, Graz, Klagenfurt, Linz, Bydgoscz, Lodz and Szczecin) and large regional airports as well (the rest of airports). Taking into account importance of the airports analyzed for development of transeuropean network there are airports serving as connecting points in the EU (Bratislava), airports serving as regional connecting point (Brno) and airports out of the transeuropean network importance (Poprad-Tatry). Besides performance characteristics we considered also typical qualitative distinctions of regional airports such as serving airlines operating point-to-point network mainly low cost carriers, high level of seasonality, significant portion of charter operation at airport, marginal importance of cargo transportation). All analyzed airports are moreover situated at destinations which are attractive as tourist centers or business centers. For our analysis we gathered twelve inputs and outputs indicators, eight of input nature (number and size of runways, number of stands, number of gates, number of check-in desk for passengers, number of baggage belts, number of aircraft parkings, number of employees, operational time, operational costs, labor costs, assets value) and four of output nature (passengers handled, cargo handled in tons, aircraft movements and total revenues). We used the input oriented DEA method with constant return on scale to reveal Super Efficiency of twenty regional airports included in analysis within 2004 – 2010.[6]

4. Results

In Table 2 we gathered the results of efficiency analysis applied to twenty regional airports in Central Europe. The results revealed that only Sczcecin airport as the only one from the list had been ineffective all the period analyzed. On the other hand, airports Bratislava, Žilina, Brno, Innsbruck, Klagenfurt, Linz, Salzburg, Gdansk, Katowice and Krakow were effective all the period analyzed. The analysis identified airports Poprad-Tatry, Pardubice, Poznan and Wroclaw as frequently ineffective.

Overlapping the results by domicile characteristics of airports we concluded that all Austrian regional airports had been effective excepting for the result fromGraz airport in 2008. Airports Ostrava, Pardubice and Poznan recorded shift of super efficiency scores from efficiency to inefficiency levels within the period analyzed. Going through ownership characteristics of airports identified as effective by DEA method we find within effective airports different governance models: Bratislava airport in central government ownership, Graz airport in decentralized public ownership, Brno airport in public ownership, however operated by a private company or airports in central public (government) ownership operated by entity composed of different public owners according to country administration levels (Gdansk, Katowice), Klagenfurt is in a mixed public-private partnership. Although being static, our analysis revealed size of catchment area and demands fluctuation as determinants of efficiency result.

4. Conclusions

As airports are unique operational and economic entities any assessment of their economic performance is undermined by many influencing factors. Time scope of analysis, compass of airports evaluated, methodology used, data availability – are the most relevant among them. In our analysis we used input oriented DEA super-efficiency approach to identify and compare efficiency of twenty regional airports in Central Europe within eight consecutive years encompassing the EU biggest enlargement year 2004, as well as years of economic crises 2009 and 2010. Bratislava airport efficiency score seem to be satisfactory within the sample analyzed. However, just enlistment of Bratislava airport among airports analyzed may be considered as the most controversial in our methodology as it is the only capital airport within the sample investigated. On the other hand, Bratislava airport is according to its performance fully comparable with airports in Innsbruck and Salzburg and three Polish airports analyzed Krakow, Katowice and Gdansk are almost bigger ones. Uniqueness of Bratislava airport consists in shared catchment area with another European Union capital airport in Vienna – a factor that is really very specific compared with other airports in our research. Albeit, taking into consideration qualitative feature of Bratislava airport, it corresponds to characteristics of regional airports in prevailing aspects of its operation. Therefore, to achieve complex evaluation of Bratislava airport efficiency, the satisfactory DEA efficiency scores of Bratislava we identified ought to be confronted within the sample of European capital airports, i.e. going out of the regional airports scope will be necessary in further research to dispose of arguments pros or cons against still vivid ideas of Bratislava airport privatization.

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[5] Our original intention to work also with regional airports in Hungary failed due to data insufficiency.

[6] We used also output oriented DEA method considering not only constant return on scale but also variable return on scale. As the results are conforming with those we mention in the text of the paper for input oriented DEA with constant return on scale.

Table 2. Super Efficiency Score of Regional Airports in Central Europe by DEA method 2004-2010

	Year							Average 04-10	Rank based on average score 04-10	Rank 2010
	04	05	06	07	08	09	10			
Bratislava	2.686	3.512	1.961	1.688	2.021	2.456	1.917	2.320	5.	6.
Košice	1..540	**0.864**	**0.889**	1.276	1.207	1.074	1.049	1.128	12.	13.
Poprad/Tatry	**0.724**	**0.873**	**0.959**	1.084	**0.790**	**0.800**	1.010	0.891	19.	14.
Žilina	5.692	10.714	5.194	4.516	4.144	4.555	6.000	5.830	2.	2.
Brno	2.404	2.196	2.698	2.767	3.198	4.433	2.711	2.915	3.	3.
Ostrava	1.463	1.414	1.029	**0.878**	**0.757**	**0.814**	**0.856**	1.030	16.	18.
Pardubice	2.050	2.010	3.279	2.445	1.578	**0.801**	**0.930**	1.870	9.	17.
Graz	1.260	1.158	1.117	1.008	**0.939**	1.060	1.008	1.079	14.	15.
Innsbruck	1.604	1.434	1..340	1..328	1.440	1.488	1.415	1.430	11.	9.
Klagenfurt	2.598	2.519	2.259	2.304	2.098	2.250	2.451	2.068	6.	5.
Linz	8.460	8.190	8.424	7.350	1.131	4.343	7.388	6.469	1.	1.
Salzburg	2.074	2.226	2.080	1..927	1.675	1.589	1.594	1.889	8.	8.
Bydgoszcz	**0.549**	**0.699**	**0.828**	**0.737**	1.047	1.286	1.129	0.896	18.	11.
Gdansk	1.104	1.117	1.529	1.605	1.734	1.927	1.666	1.526	10.	7.
Katowice	1.525	1.611	1.483	1.542	4.626	1.270	1.322	1.911	7.	10.
Krakow	2.054	2.306	2.626	2.668	2.972	2.919	2.685	2.604	4.	4.
Lodz	**0.814**	**0.892**	1.116	1.278	1.268	1.014	1.082	1.066	15.	12.
Poznan	1.249	**0.921**	1.175	**0.678**	**0.724**	**0.771**	**0.776**	0.899	17.	20.
Szczecin	**0.615**	**0.596**	**0.564**	**0.711**	**0.785**	**0.876**	**0.854**	0.714	20.	19.
Wroclaw	**0.872**	**0.915**	1.124	1.078	1.188	**0.947**	1.006	1.119	13.	16.

Source: Own Computation based on annual reports data.

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